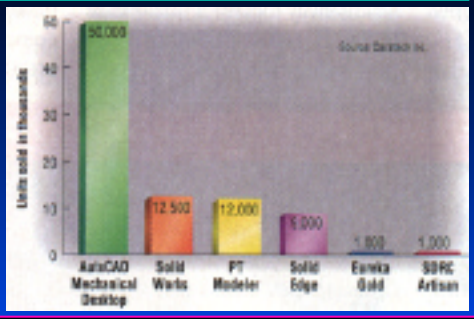
Graphics Examples

SIGGRAPH 2001

Source: Computer Graphics World Magazine

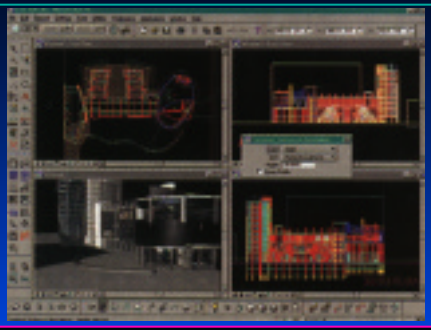


1

Graphics Examples

SIGGRAPH 2001

Source: MicroStation TriForma



2

Graphics Examples

SIGGRAPH 2001

Source: Box Studios/GRS Greiner Columbus Ohio

3

Graphics Examples

Source: "Wass" by Li Chen (Computer Graphics World Magazine)

4

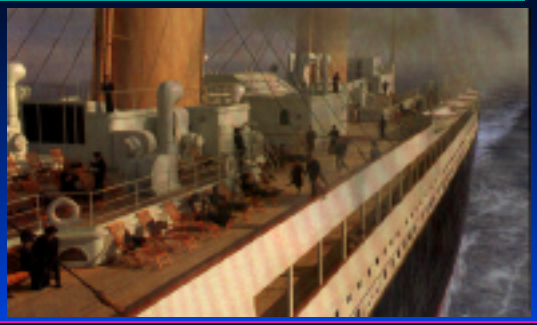
Graphics Examples

Source: Kinetix, A Division of Autodesk

5

Graphics Examples

Source: Digital Domain, ©20th Century Fox/ Paramount Pictures



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Graphics Examples

Source: Michael Salisbury, et al, University of Washington

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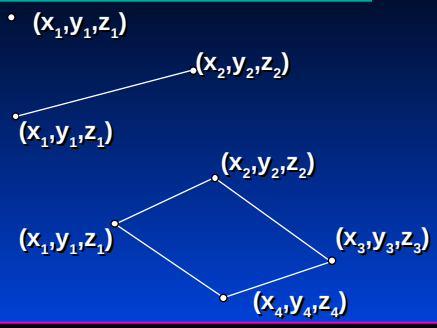
Picture Primitives

- Point
- Line
- Polygon



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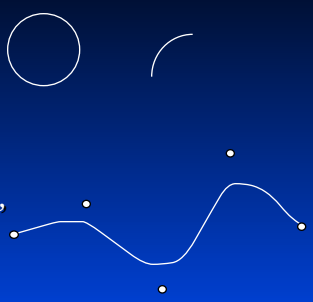
Picture Primitives

- Circle /Arc
- Curve

Bezier, polynomial,
b-spline,
NURB, ...



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Picture Primitives

- Patch

  Coons, Bezier, b-spline, NURB, ...

- Solid

  cube, cylinder, cone, sphere, ...

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Picture Primitives

- Text
  - outline

    (eg, PostScript, TrueType)

  - bit-mapped

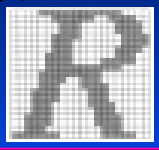

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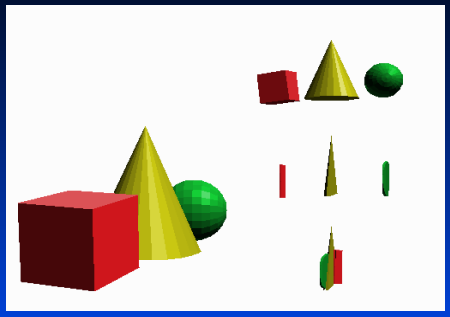
Image Dimensions



3-D

2.5-D

2-D

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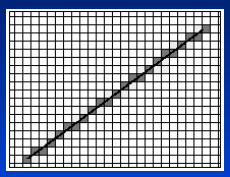
Scan Conversion

Lines

For each column or row in the frame buffer, color the pixel whose center is nearest the true line



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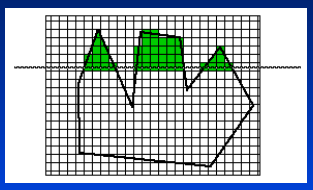
Scan Conversion

Polygons

For each pixel in the scan line, color it if its center is inside the polygon



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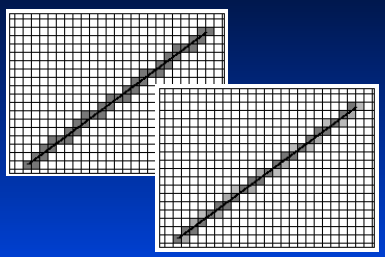
Scan Conversion

Antialiasing



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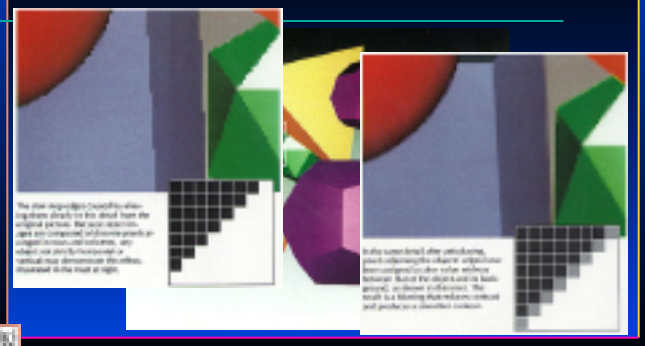
Antialiasing

Source: Time-Life Books, "Understanding Computers - Computer Images"



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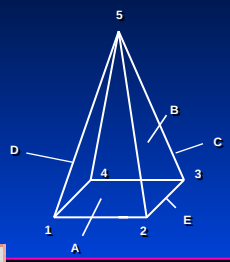
Modeling

Polygon Data Structure



Face List	
Face	Vertices
A	1 2 5
B	2 3 5
C	3 4 5
D	1 4 5
E	1 2 3 4

Vertex List	
Vertex	x,y,z
1	0,0,0
2	2,0,0
3	2,0,2
4	0,0,2
5	1,3,1

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Modeling - Techniques

- Extrusion
- Surface of Revolution
- Lofting
- 3D Digitizing
- Free-form curves and surfaces
- Solids Modeling

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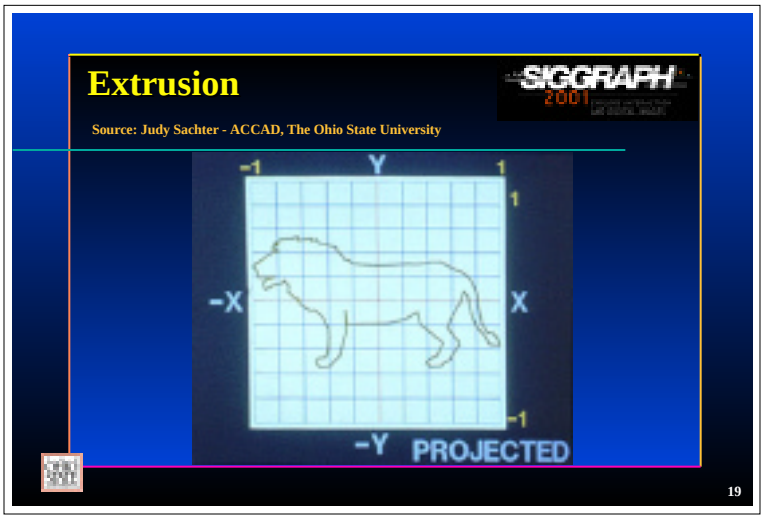
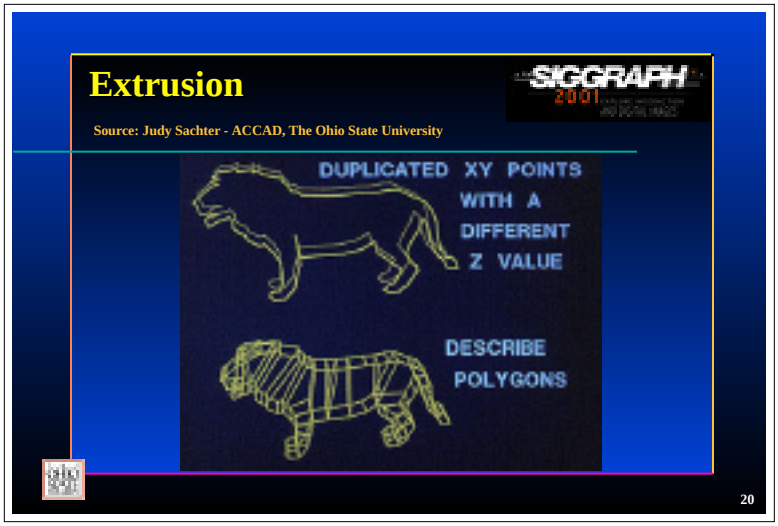
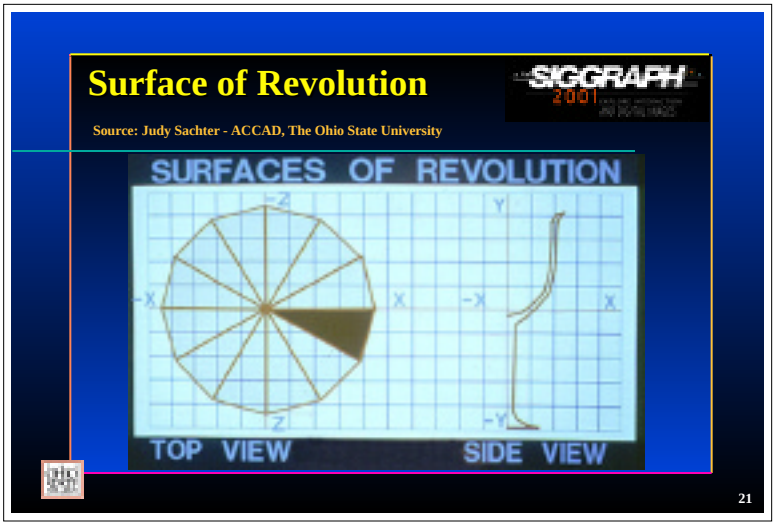

Extrusion
SIGGRAPH 2001
Source: Judy Sachter - ACCAD, The Ohio State University
-1
Y
1
1
-X
X
-1
-Y PROJECTED
19


Extrusion
SIGGRAPH 2001
Source: Judy Sachter - ACCAD, The Ohio State University
DUPLICATED XY POINTS WITH A DIFFERENT Z VALUE
DESCRIBE POLYGONS
20


Surface of Revolution
SIGGRAPH 2001
Source: Judy Sachter - ACCAD, The Ohio State University
SURFACES OF REVOLUTION
TOP VIEW
SIDE VIEW
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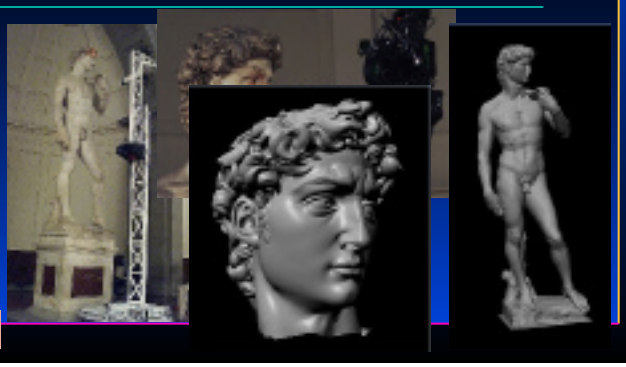
Surface of Revolution
SIGGRAPH 2001
Source: Judy Sachter - ACCAD, The Ohio State University
22


Lofting
SIGGRAPH 2001
Source: Judy Sachter - ACCAD, The Ohio State University
23


3D Digitizing
SIGGRAPH 2001
Source:Immersion Corporation
From:
Geri's Game
Pixar
24

3D Digitizing

Source: Stanford University - Marc Levoy



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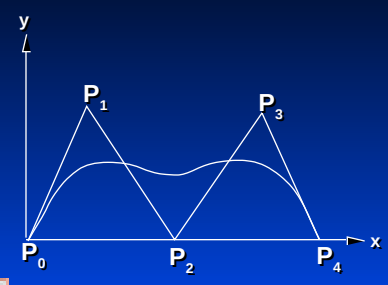
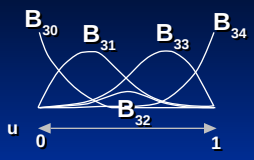
Free-form curves





$$Q(u) = \sum_{i=0}^{3} P_i B_{3i}(u)$$

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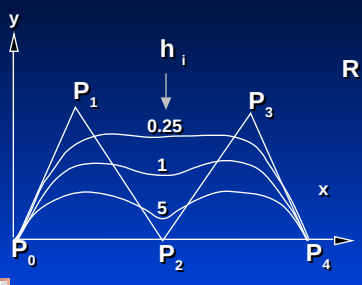
Free-form curves-NURBS

Non-Uniform Rational B-Splines



$$R_{3i}(u) = \frac{h_i B_{3i}(u)}{\sum_{i=0}^{3} h_i B_{3i}(u)}$$

$$Q(u) = \sum_{i=0}^{3} P_i R_{3i}(u)$$

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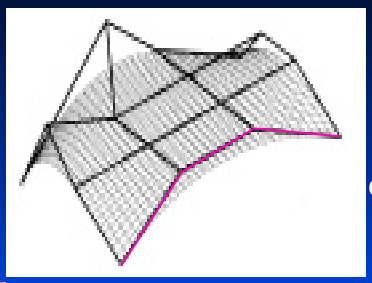
Free-form surfaces



$$Q(u,w) = \sum_{i=0}^{3}\sum_{j=0}^{3} P_{ij} B_{3i}(u) B_{3j}(w)$$

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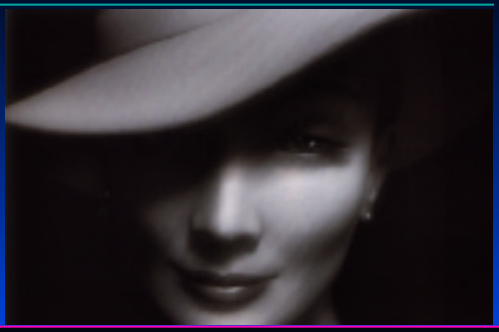
Freeform surface Patches

Source: Virtual Celebrities



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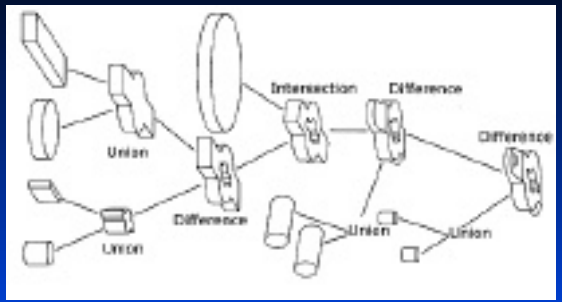
Solid Model

Source: Geometric Modeling - Mortenson, Wiley Pub.



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Solid Model

Source: Ferdie Scheepers - ACCAD, The Ohio State University

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Other Modeling Techniques

- Volumes (voxels)
- Fractals
- L-systems
- Subdivision surfaces
- Satellite remote sensing
- Obtaining geometry from photographs

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Volumes

Source: ACCAD - The Ohio State University

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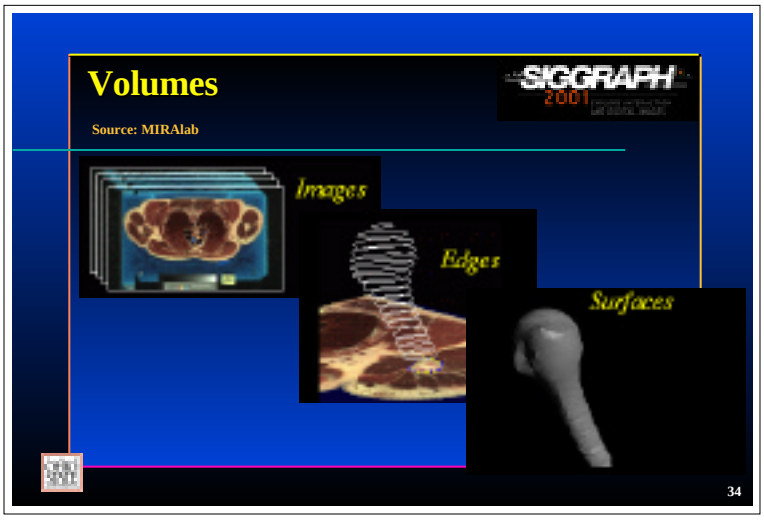
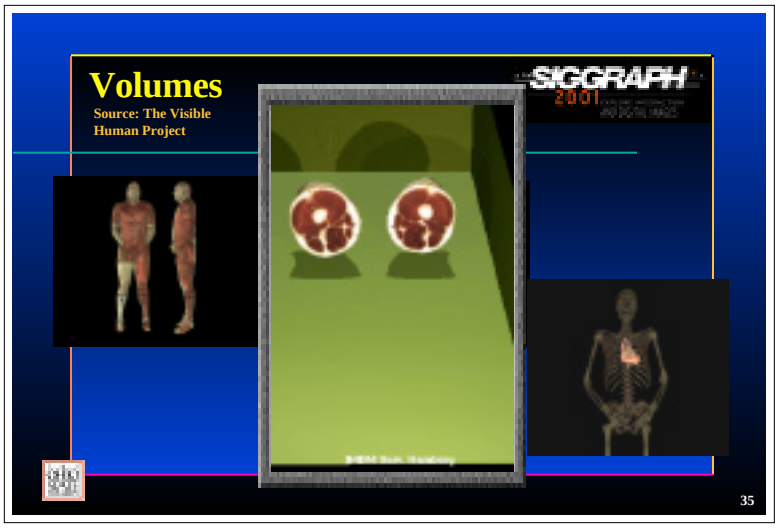

Volumes
SIGGRAPH 2001
Source: MIRAlab
Images
Edges
Surfaces
34


Volumes
SIGGRAPH 2001
Source: The Visible Human Project
35


Volumes
SIGGRAPH 2001
Source: Tiberian Sun
36

Fractals

Source: Loren Carpenter - Boeing

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L-systems

Source: Midori Kitagawa - ACCAD, The Ohio State University

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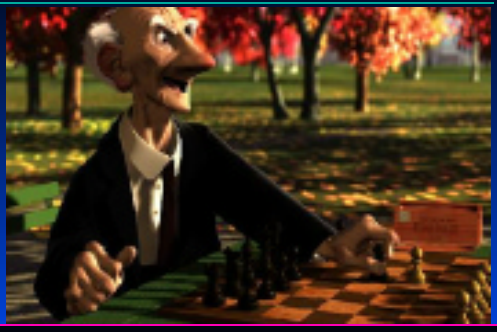
Subdivision surfaces

Source: Pixar Animation Studios



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Satellite remote sensing

Source: Jet Propulsion Laboratory and NASA

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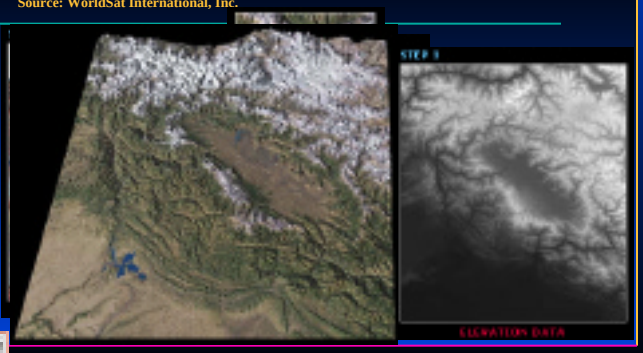
Satellite remote sensing
Draping with DEMs

Source: WorldSat International, Inc.



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Geometry from photos

Source: Pighin, et al - University of Washington

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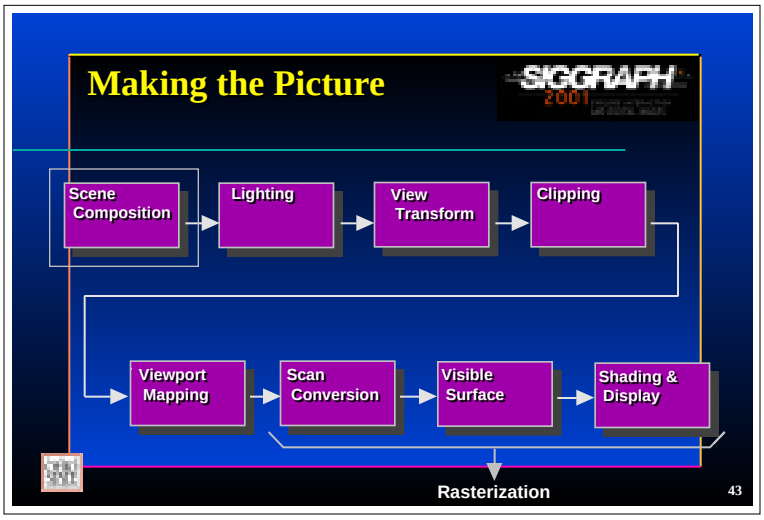
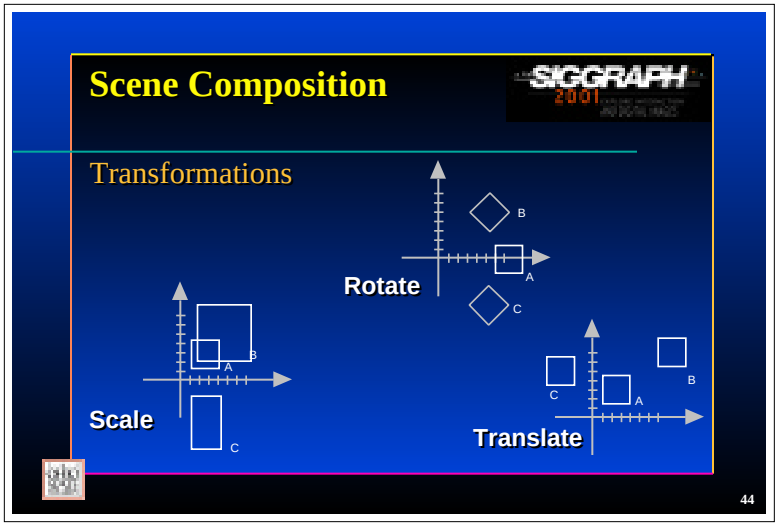
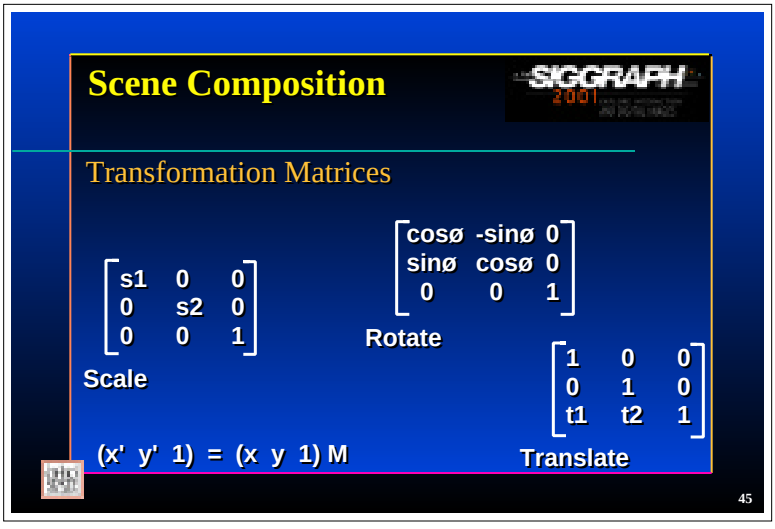
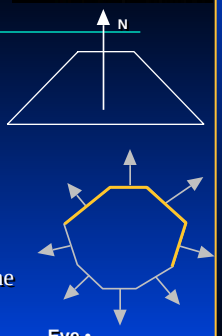

Making the Picture
SIGGRAPH 2001
Scene Composition
Lighting
View Transform
Clipping
Viewport Mapping
Scan Conversion
Visible Surface
Shading & Display
Rasterization
43


Scene Composition
SIGGRAPH 2001
Transformations
Rotate
Scale
Translate
44


Scene Composition
SIGGRAPH 2001
Transformation Matrices
s1 0 0
0 s2 0
0 0 1
Scale
cosø -sinø 0
sinø cosø 0
0 0 1
Rotate
1 0 0
0 1 0
t1 t2 1
Translate
(x' y' 1) = (x y 1) M
45

Trivial rejection

- The Normal Vector
  - Perpendicular to the polygon; provides a sense of orientation
- Backface Rejection
  - Throw away all polygons that have normal vectors pointing away from the eye



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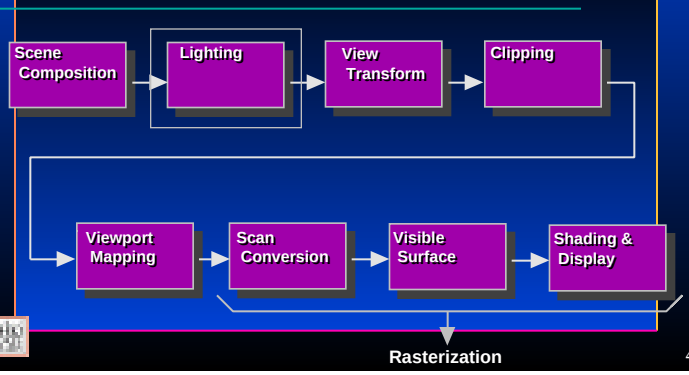
Making the Picture



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Lighting

- Sources of lights
  - *Ambient* - some light at a point on the surface comes from light reflected from other surfaces
  - *Point light source* -some light at a point on the surface comes directly from the source

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Lighting

- Surface attributes
  - *Diffuse* surfaces - light is absorbed and reemitted uniformly in all directions
  - *Specular* surfaces - light is reflected directly from the surface at the same angle as it arrives

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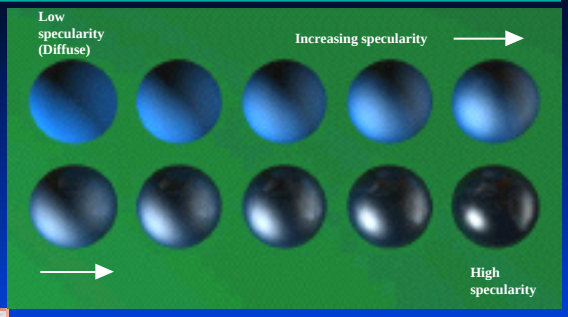
Surface Attributes

Source: Tom Coggia - ACCAD, The Ohio State University



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Lighting

- Other influences
  - *Light attenuation* - the strength of the light is reduced as a function of its distance
  - *Atmospheric attenuation* - some light is absorbed by elements of the atmosphere
  - Light *intensity* and *color*
  - Other *types* of light sources, (eg, distributed)

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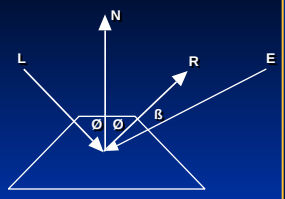
Lighting

- Lighting Models
  - Lambert model

$I = k_a + k_d * \cos ø$



  - Specular Reflection
    - Phong Model

$I = k_a + k_d * \cos ø + k_s * (\cos ß)^n$

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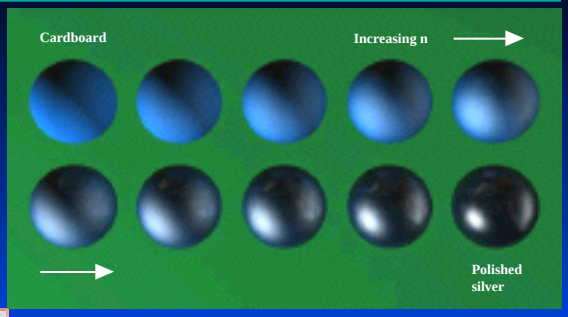
Phong Specular Reflection

$I = k_a + k_d * \cos ø + k_s * (\cos ß)^n$



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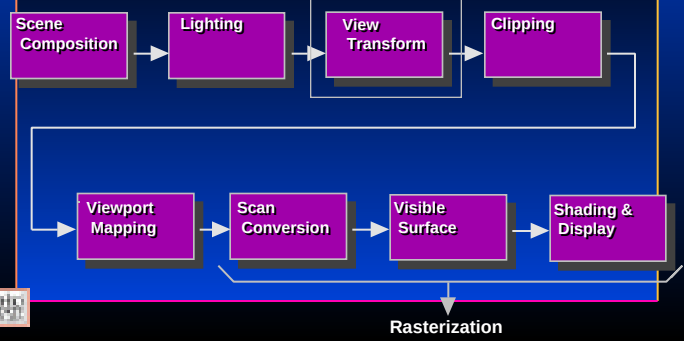
Making the Picture



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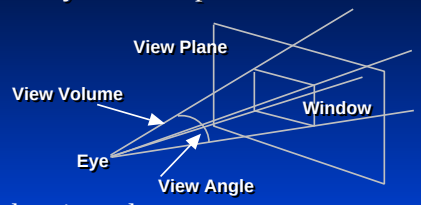
View Transform

- Transform data from world coordinates into the space defined by the view parameters



- Project onto the view plane

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View Transform

- Projections
  - *Orthographic (Parallel)*
    - The projectors through the coordinates of the objects never converge
  - *Perspective*
    - The projectors through the coordinates of the objects converge at a point (the Center of Projection)

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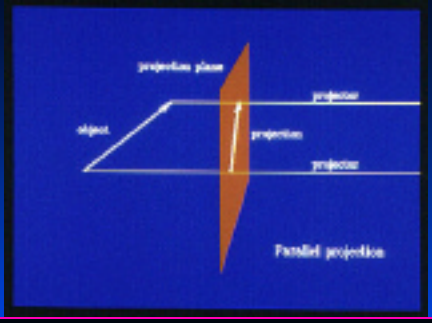
Parallel Projection (Orthographic)

Source: SIGGRAPH Educators' Slide Set (1994)



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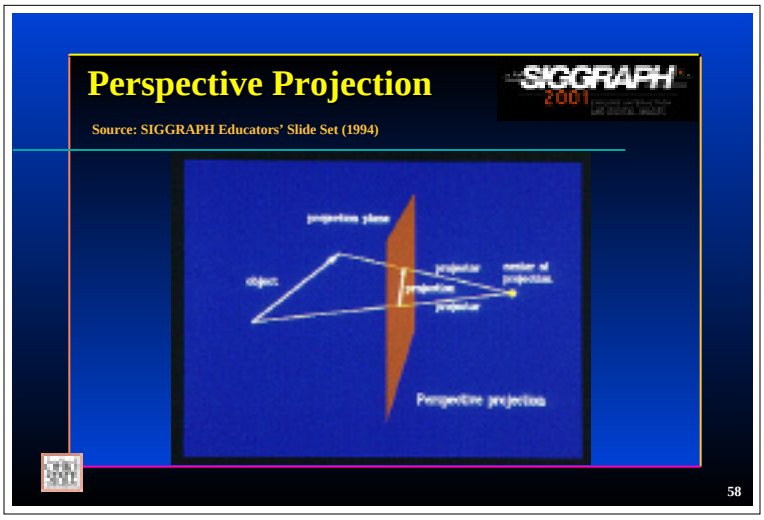
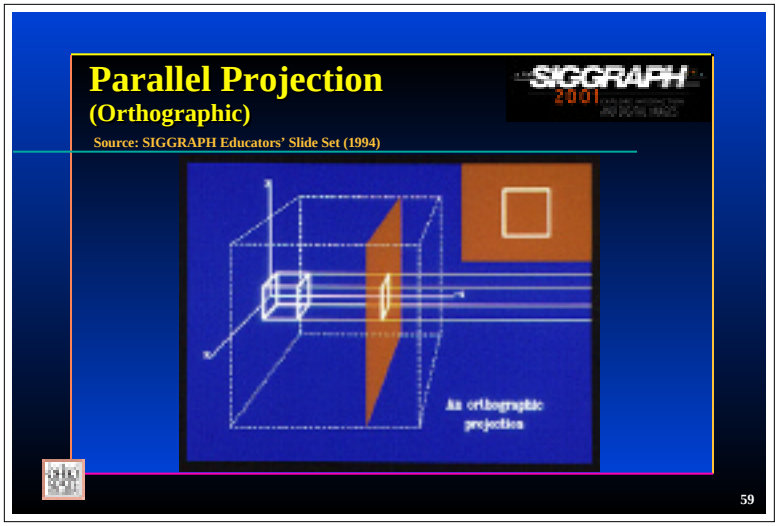
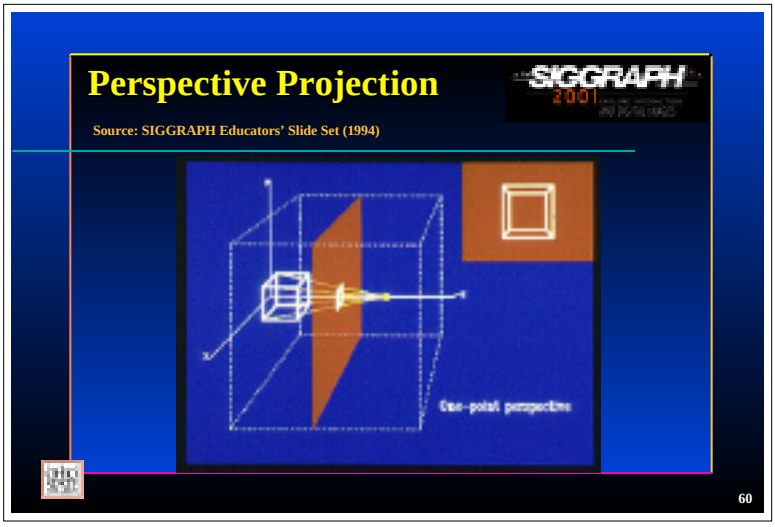
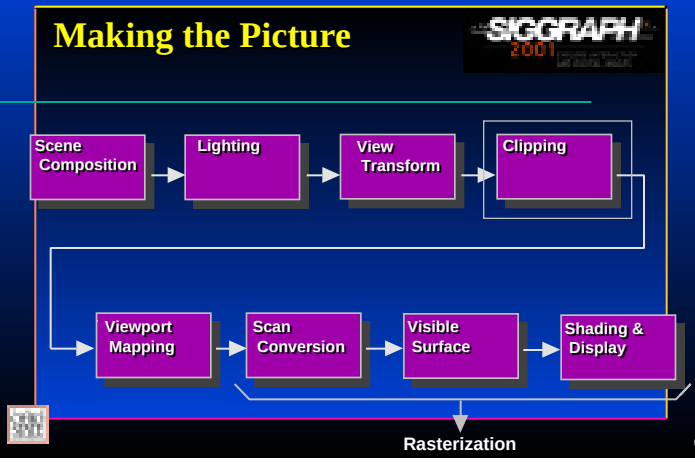

Perspective Projection
SIGGRAPH 2001
Source: SIGGRAPH Educators' Slide Set (1994)
projection plane
object
projector
center of projection
projector
Perspective projection
58


Parallel Projection
(Orthographic)
SIGGRAPH 2001
Source: SIGGRAPH Educators' Slide Set (1994)
An orthographic projection
59


Perspective Projection
SIGGRAPH 2001
Source: SIGGRAPH Educators' Slide Set (1994)
One-point perspective
60

Making the Picture



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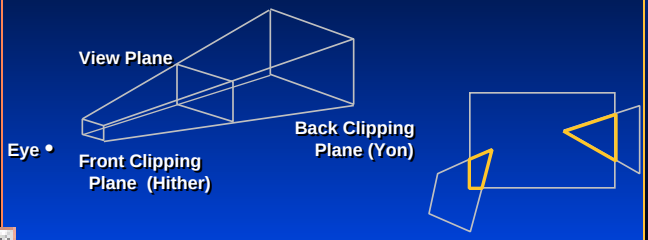
Clipping

Remove all parts of any primitive that are outside the boundaries of the view volume



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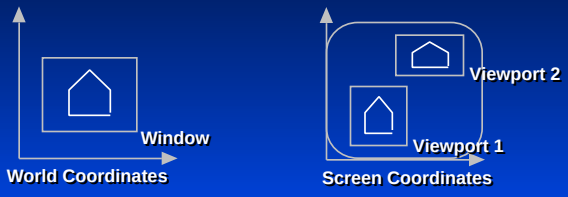
Viewport Mapping

Transform the projected image from the window in the view plane to the viewport in which it will be displayed



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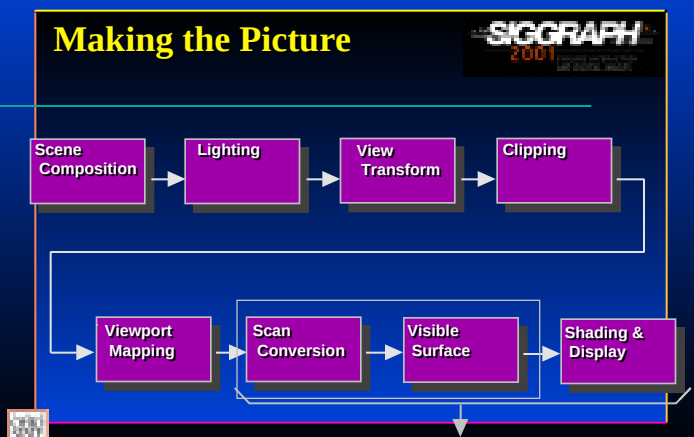
Making the Picture



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Rasterization

- Hidden Line
  - Remove all lines or parts of lines that wouldn't be seen if the objects were solid
- Visible Surface
  - Display only those faces or parts of faces that are visible by virtue of being closer to the eye than others
    - depth sorting
    - z - buffer

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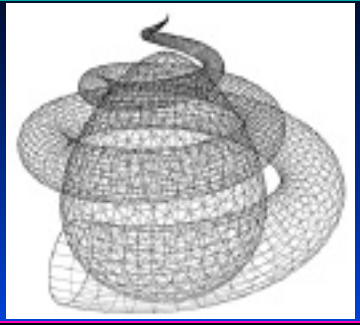
Line drawing

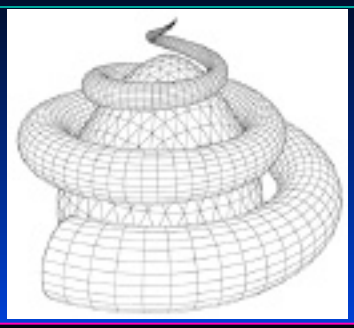
Source: Visulization (Friedhoff & Benzon - Abrams Pub.)



66

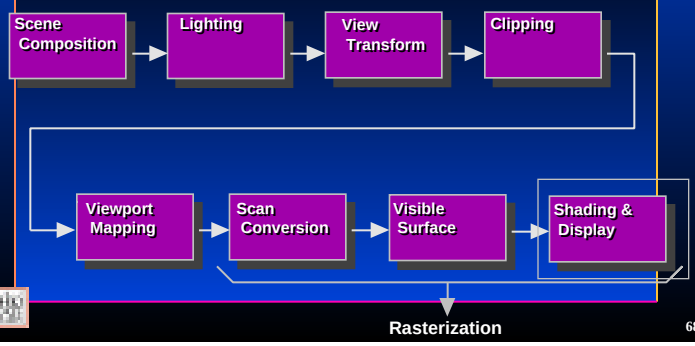
Hidden line drawing

Source: Visulization (Friedhoff & Benzon - Abrams Pub.)



67

Making the Picture



68

Shading

Shading Models

- Faceted (Flat shading)
  All intensities are the same across the polygon.
- Gouraud smooth shading
  Intensities across the polygon are interpolated
- Phong smooth shading
  Intensities across the polygon are calculated from interpolated normal vectors

69

Faceted shading

Source: Visulization (Friedhoff & Benzon - Abrams Pub.)

70

Gouraud smooth shading

Source: Visulization (Friedhoff & Benzon - Abrams Pub.)

71

Phong smooth shading

Source: Visulization (Friedhoff & Benzon - Abrams Pub.)

72

Shading

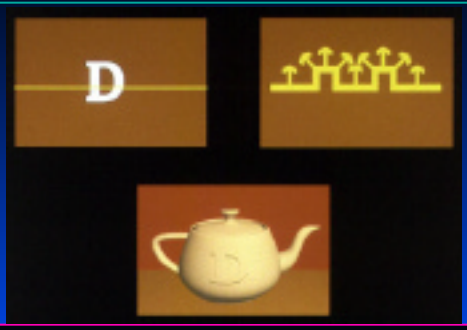
Surface Effects

- Texture Mapping
  - Bump Mapping (Displacement Mapping)
  - 2D textures
  - 3D (Solid) textures
- Transparency
- Shadows
- Environment Mapping (Reflection Mapping)
- Procedural Shaders (RenderMan)

73

Bump Mapping

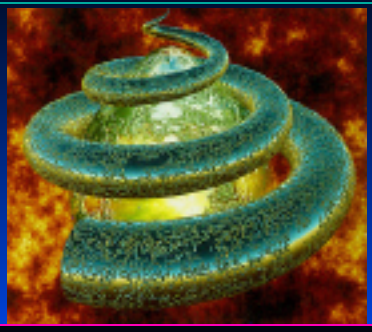
Source: SIGGRAPH Educators' Slide Set (1997)



74

Bump mapping

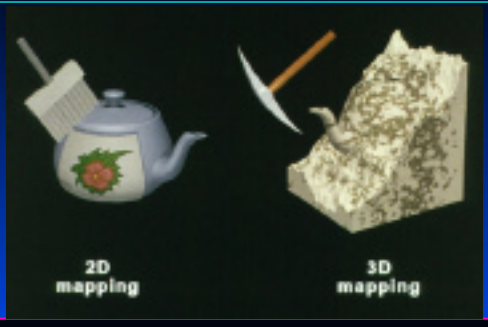
Source: Visulization (Friedhoff & Benzon - Abrams Pub.)



75

Texture Mapping

Source: SIGGRAPH Educators' Slide Set (1997)



76

Texture Mapping

Source: Visulization (Friedhoff & Benzon - Abrams Pub.)

77

Solid Texture Mapping

Source: David Ebert - The Ohio State University

78

Transparency

Source: Visulization (Friedhoff & Benzon - Abrams Pub.)

79

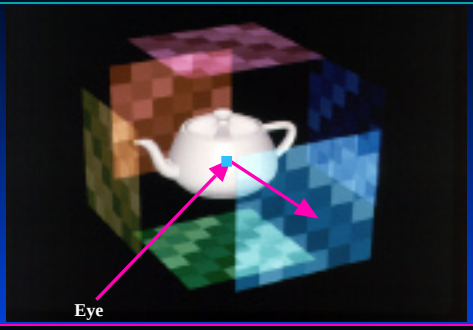
Shadows

Source: Illumination and Color in CGI - Roy Hall, S-V Pub.

80

Environment Mapping

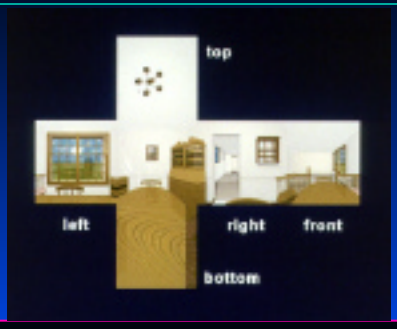
Source: SIGGRAPH Educators' Slide Set (1997)



81

Environment Mapping

Source: SIGGRAPH Educators' Slide Set (1997)



82

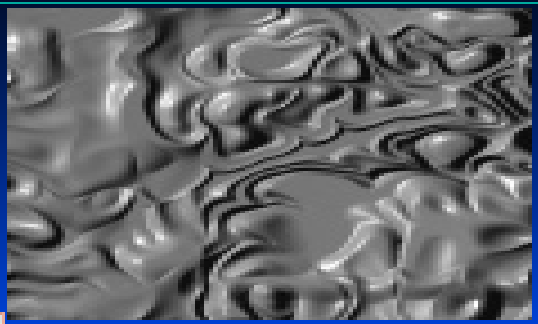
Environment Mapping

Source: SIGGRAPH Educators' Slide Set (1997)

83

RenderMan Shaders

Source: Heath Hanlin - ACCAD, The Ohio State University



84

RenderMan Shaders

Source: Heath Hanlin - ACCAD, The Ohio State University

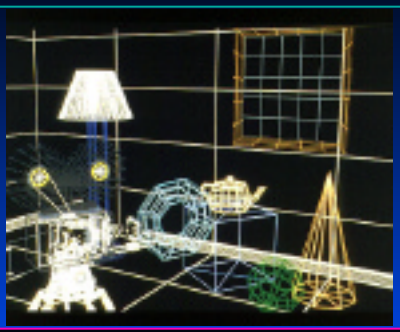
```
Cij = 0;
 for (f = 1; f < 0.5 * cutoff; f *= 2)
   turb += abs(snoise(PP * f)) / f;
 fade = clamp(10 * (cutoff - f) / cutoff, 6, 10);
 turb += fade * abs(snoise(PP * f)) / f;
 turb *= 0.5;
tt = float noise(t * complexity * turb);
layer_color = one;
layer_opac = smoothstep(.1,.9,tt) - .3;
surface_color = blend(surface_color, layer_color, layer_opac);
ss = float noise(s * -complexity * (-turb * .5));
layer_color = two;
layer_opac = smoothstep(.1,.9,ss) - .3 ;
surface_color = blend(surface_color, layer_color, layer_opac);
tt = float noise(PP * complexity * turb);
layer_color = three;
layer_opac = smoothstep(.1,.9,tt) - .3 ;
surface_color = blend(surface_color, layer_color, layer_opac);
   Nf = faceforward(normalize(N), I);
   V = -normalize(I);
   surface_color = surface_color * (Ka * ambient() + Kd * diffuse(Nf)) + specularcolor *
                   Ks * specular(Nf, V, roughness);
e_opac;
Cij = surface_color * surface_opac;
```

• Cij

85

Shutterbug - Wire frame

Source: Pixar



86

Shutterbug - Hidden Line

Source: Pixar

87

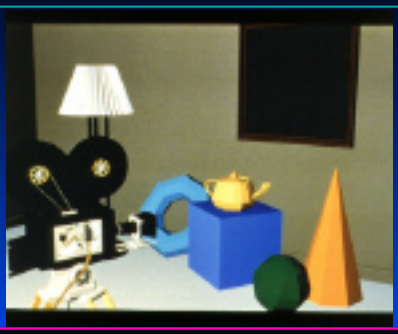
Shutterbug - Ambient

Source: Pixar

88

Shutterbug - Faceted

Source: Pixar



89

Shutterbug - Gouraud

Source: Pixar

90

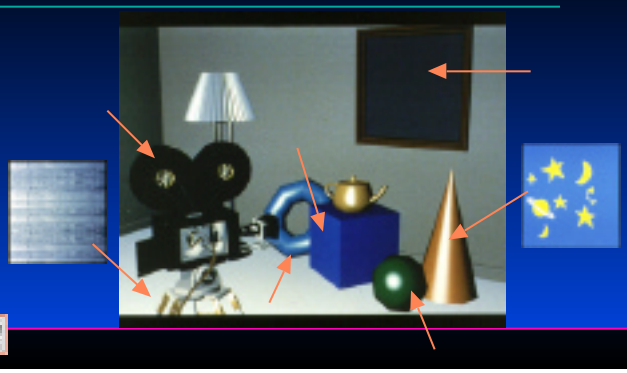
Shutterbug - Phong

Source: Pixar

91

Shutterbug - Textures

Source: Pixar



92

Shutterbug - Textures

Source: Pixar

93

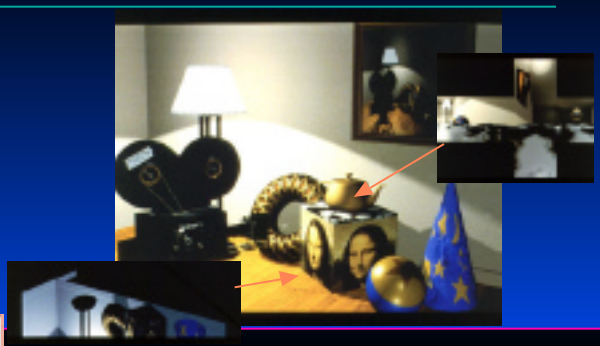
Shutterbug - Shadows

Source: Pixar

94

Shutterbug - Reflections

Source: Pixar



95

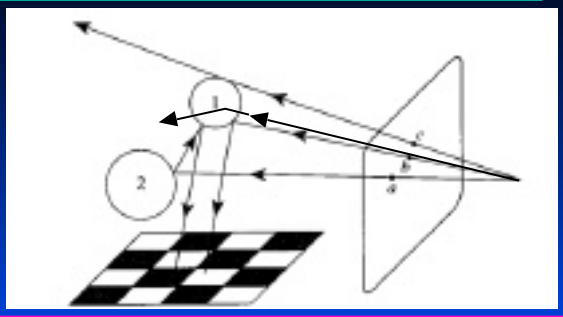
Shutterbug - Reflections

Source: Pixar

96

Ray Tracing

Source: Computer Graphics - Pokorny, Franklin-Beedle Pub.



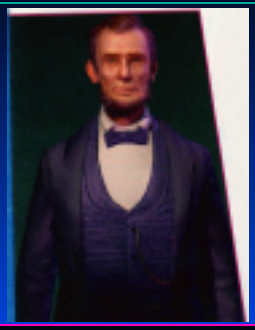
97

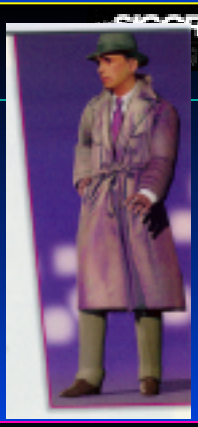
Ray Tracing

Source: Shaun Ho - Cranston/Csuri Productions

98

Digital actors





99

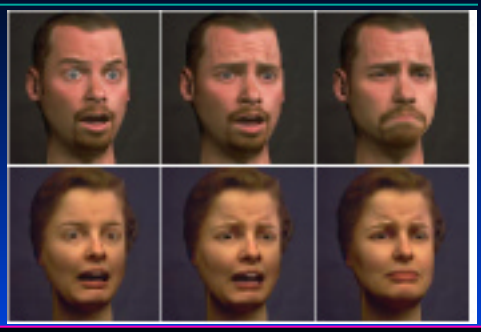
Digital actors (Synthespians)

- Facial features
- Clothing
- Hair and fur
- Muscles and skin
- Compositing real images with synthetic images
- Motion

100

Facial features

Source: Pighin, et al - University of Washington



101

Clothing

Source: Baraff and Witkin - Carnegie Mellon University

102

Hair and fur

Source: Goldman - ILM (101 Dalmations © Disney 1996)

103

Hair and fur

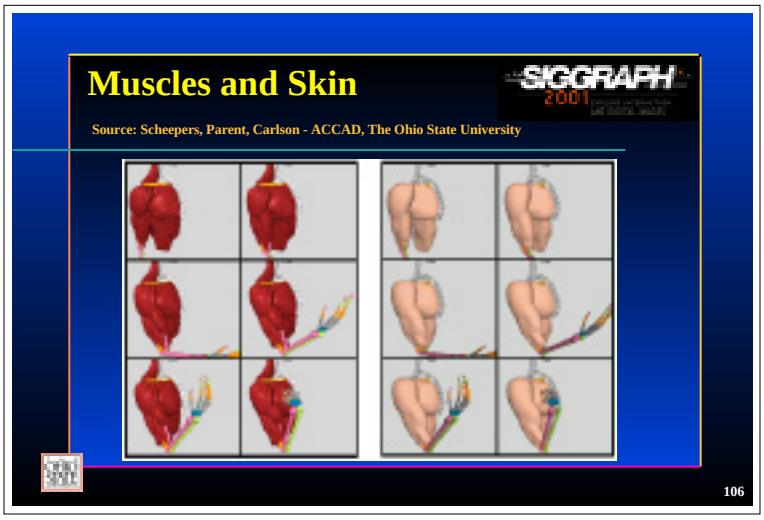
Source: Chris Wedge - Blue Sky Productions (Bunny, 1998)

104

Hair and fur

Source: PDI/Dreamworks

105

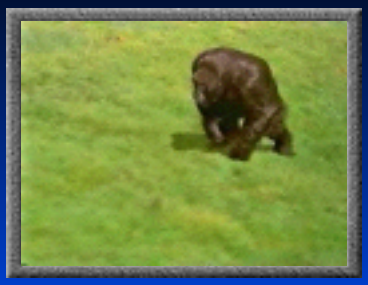

Muscles and Skin
SIGGRAPH 2001
Source: Scheepers, Parent, Carlson - ACCAD, The Ohio State University
106


Compositing synthetic and real
SIGGRAPH 2001
107


Compositing synthetic and real
SIGGRAPH 2001
108

Compositing synthetic and real

Source: DreamQuest Images (Mighty Joe Young ©Disney 1998)



109

Compositing synthetic and real

Source: Digital Domain, ©20th Century Fox/ Paramount Pictures

110

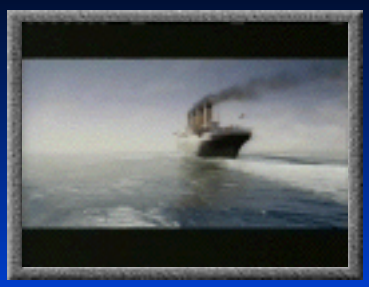
Compositing synthetic and real

Source: Digital Domain, ©20th Century Fox/ Paramount Pictures

111

Compositing synthetic and real

Source: Digital Domain, ©20th Century Fox/ Paramount Pictures



112

Compositing synthetic and real

Source: Digital Domain, ©20th Century Fox/ Paramount Pictures

113

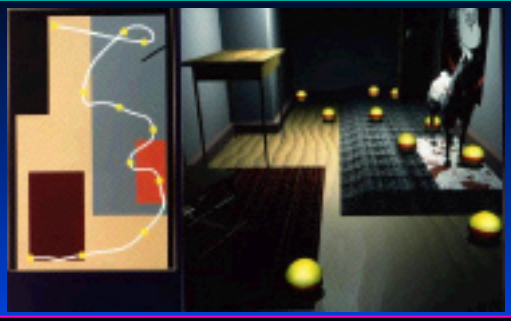
Animation

- Explicit animation control
  - Motion Path / Key-framing / Track-based
- Procedural control
  - Particle system / Physical-based / Constraints
- Metamorphosing (Morphing)
- Motion tracking
  - Rotoscoping / Motion capture
- External control
  - Simulation / MIDI control

114

Motion Path

Source: ACCAD - The Ohio State University



115

Motion Path Example

Source: Hsuen Ho - Cranston/Csuri Productions

116

Key Framing

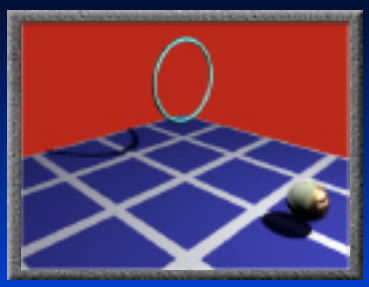
2 key frames (determined by animator)

In between frames (calculated by computer)

117

Key Framing Example

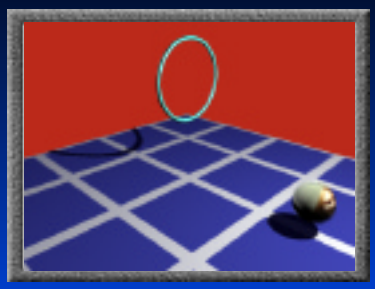
Source: Mimi Brown - ACCAD WomenAndTech Summer Program



118

Key Framing Example

Source: Mimi Brown - ACCAD WomenAndTech Summer Program



119

Track Based Example

Source: Susan Van Baerle - Cranston/Csuri Productions

120

Procedural Control

Source: ACCAD - The Ohio State University

121

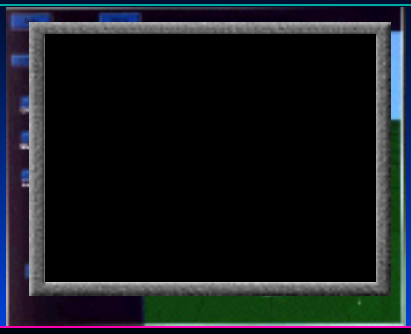
Procedural Control Physical Based

Source: James Hahn - ACCAD, Ohio State University

122

Particle Systems

Source: ACCAD - The Ohio State University

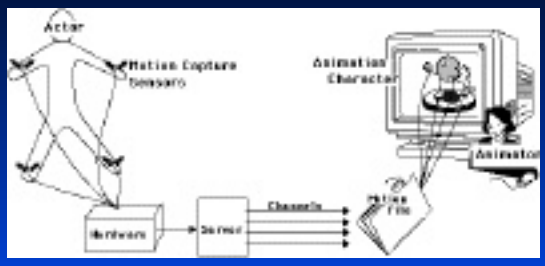


QuickTime - The Perfect Storm ILM and Warner Bros.

123

Motion Tracking

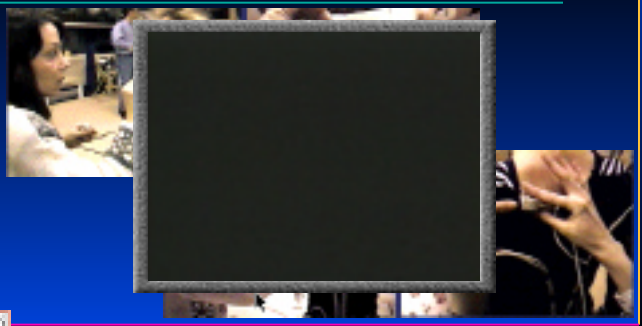
Source: Scott Dyer - Windlight Studios



124

Motion Tracking

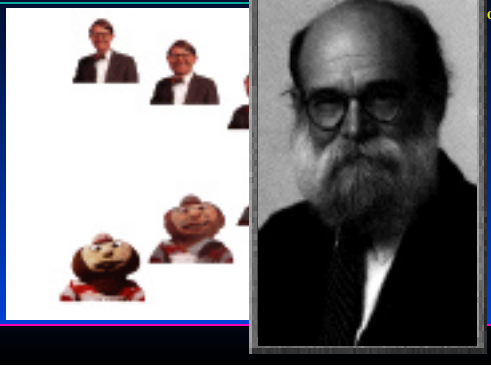
Source: Susan Van Baerle - LambSoft



125

2D Image Morphing

Source: ACCAD - The Ohio State University



QuickTime From:
David Johnson
Univ. of Utah

126

3-D Object Morphing

Source: ACCAD - The Ohio State University

127

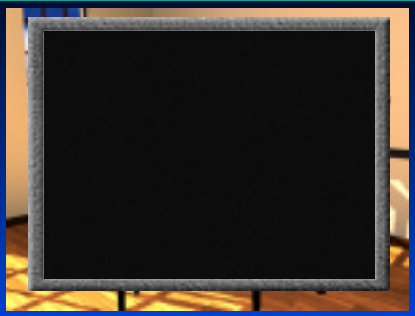
Simulation

Source: NCSA - University of Illinois

128

MIDI External Control

Source: Steve May, et al - ACCAD, The Ohio State University



129